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(54) **ORGANIC LIGHT-EMITTING DIODE  
FLUORESCENT DEVICE AND METHOD  
FOR PRODUCING SAME**

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**H01L 51/00** (2006.01)

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See application file for complete search history.

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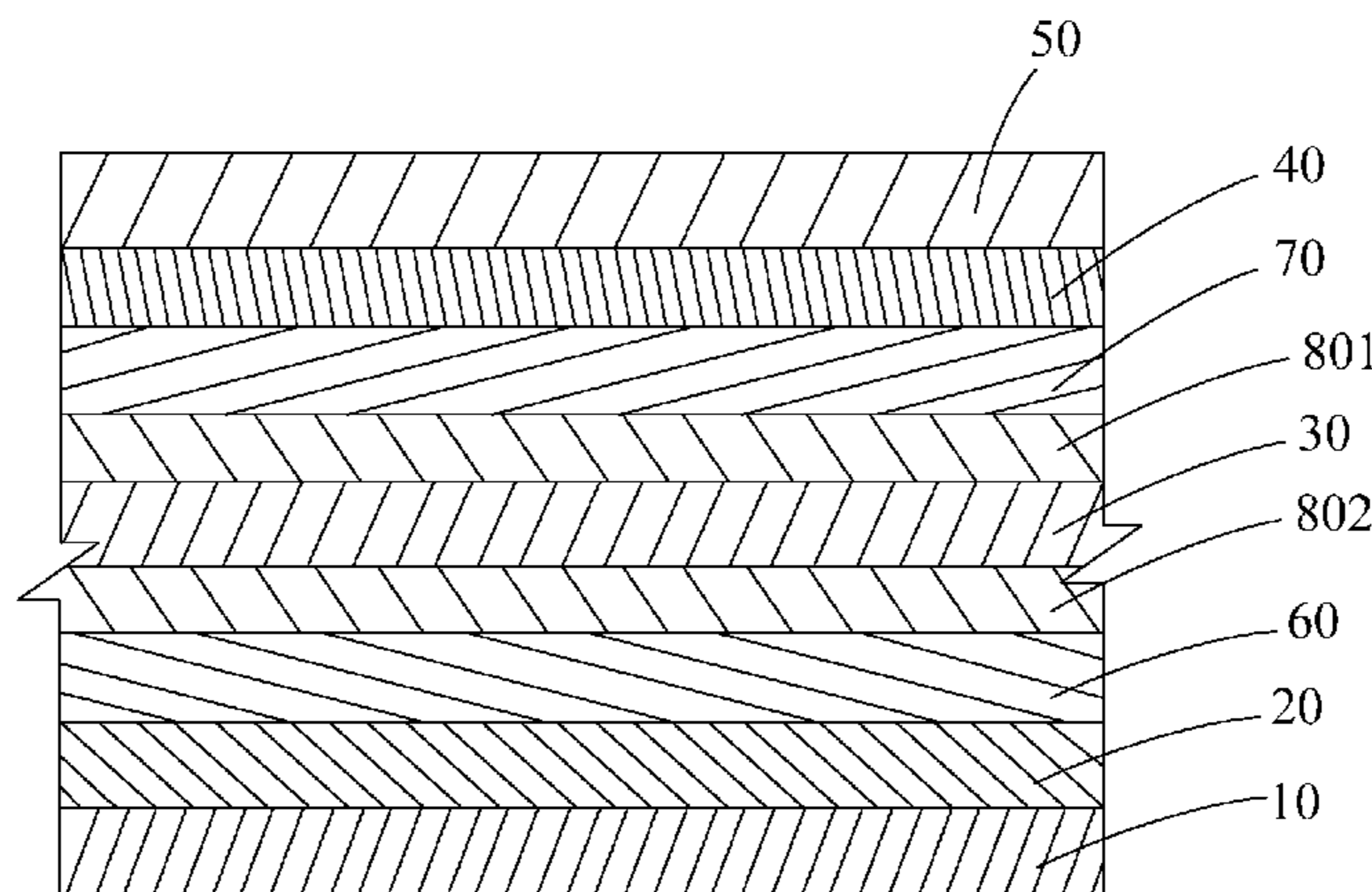
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(57) **ABSTRACT**

An organic light-emitting diode fluorescent device includes an anode layer, a hole injection layer, an emissive layer, an electron injection layer, and a cathode layer. A confinement layer is disposed on at least one of an upper face and a lower face of the emissive layer. The confinement layer has a triplet energy level higher than a triplet energy level of the emissive layer. A method for producing the organic light-emitting diode fluorescent device includes providing an anode substrate as an anode layer and disposing a hole injection layer, an emissive layer, an electron injection layer, and a cathode layer on the anode layer in sequence. A confinement layer is disposed on at least one of an upper face and a lower face of the emissive layer while producing the emissive layer. The confinement layer has a triplet energy level higher than a triplet energy level of the emissive layer.

**18 Claims, 2 Drawing Sheets**



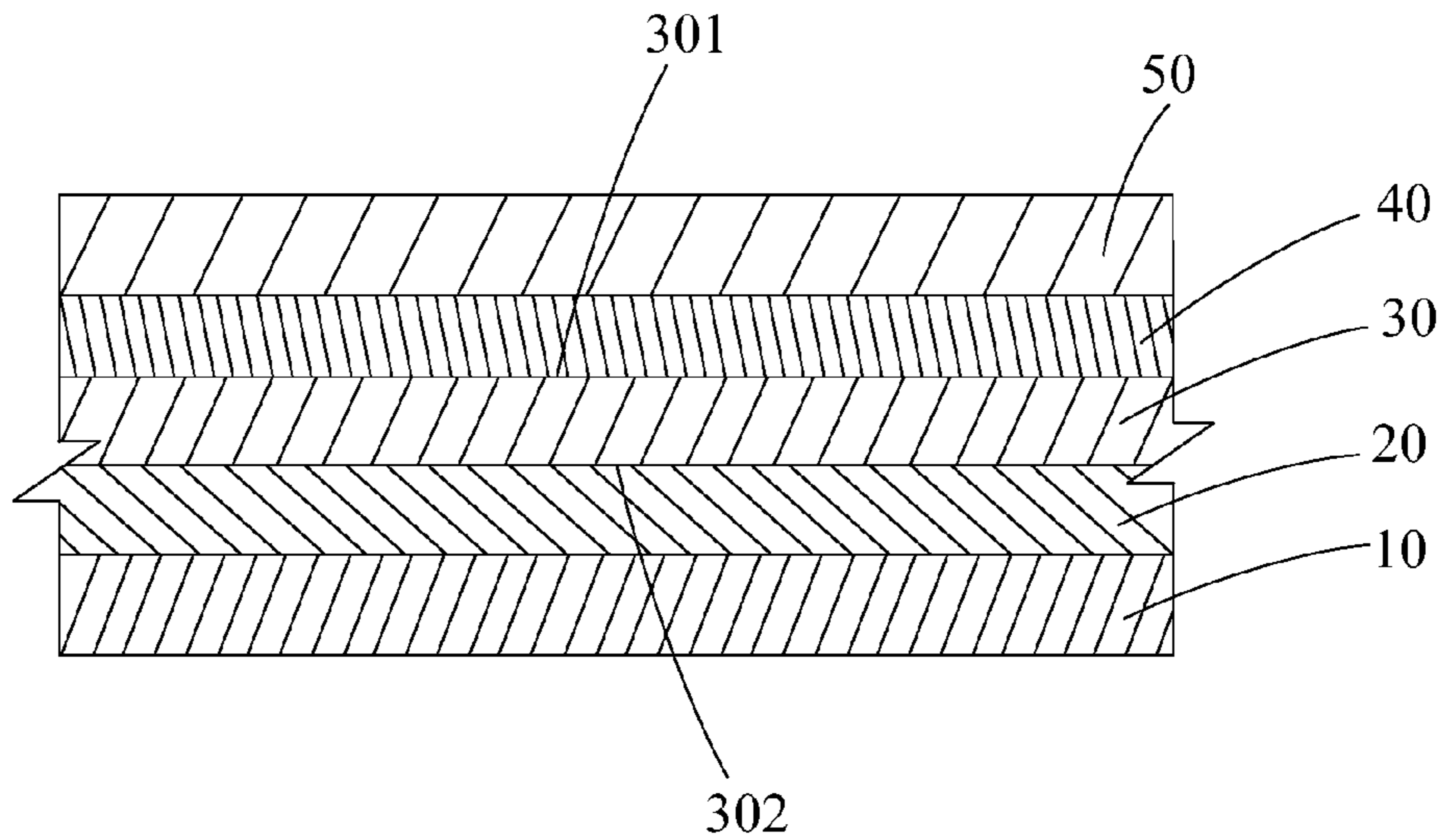


Fig. 1

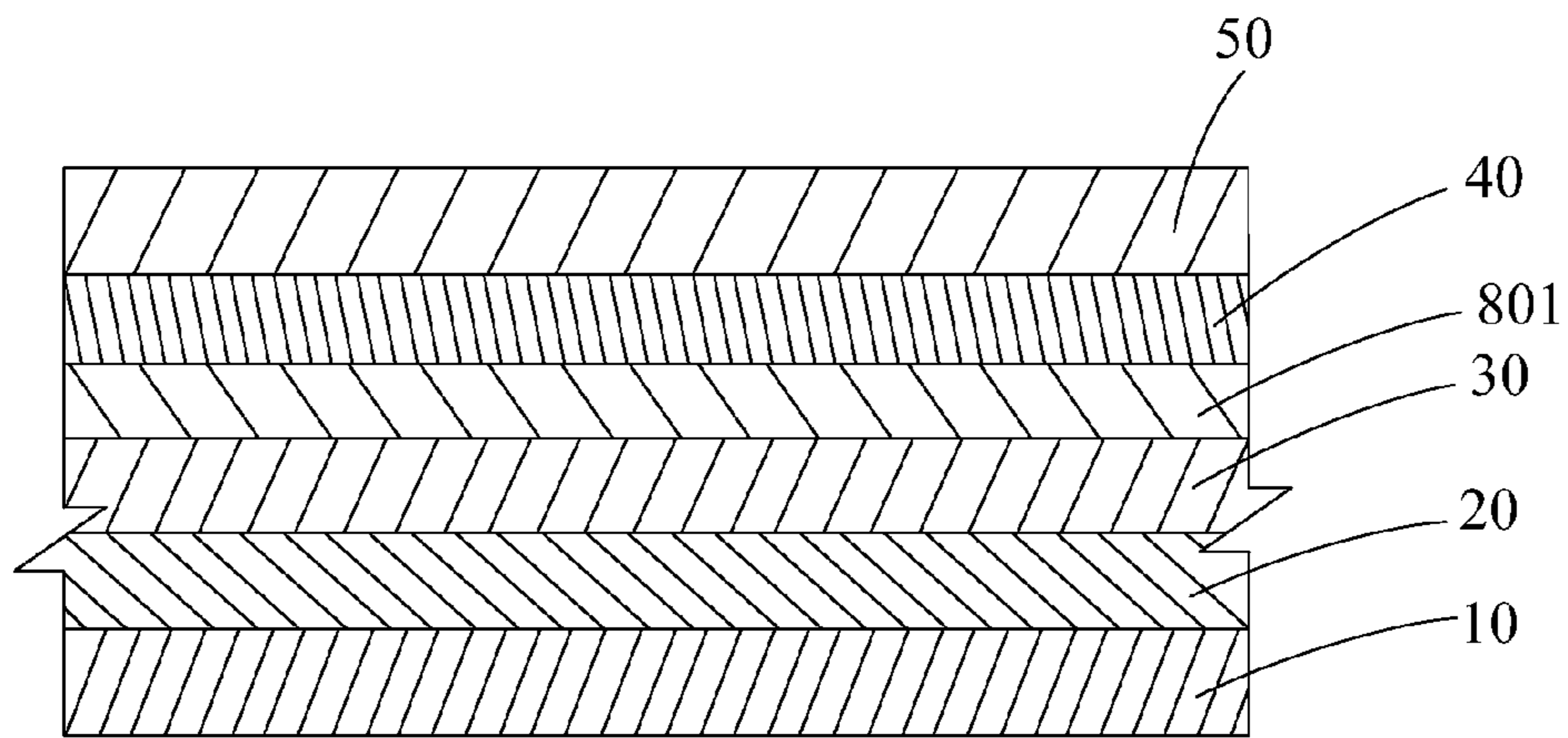


Fig. 2

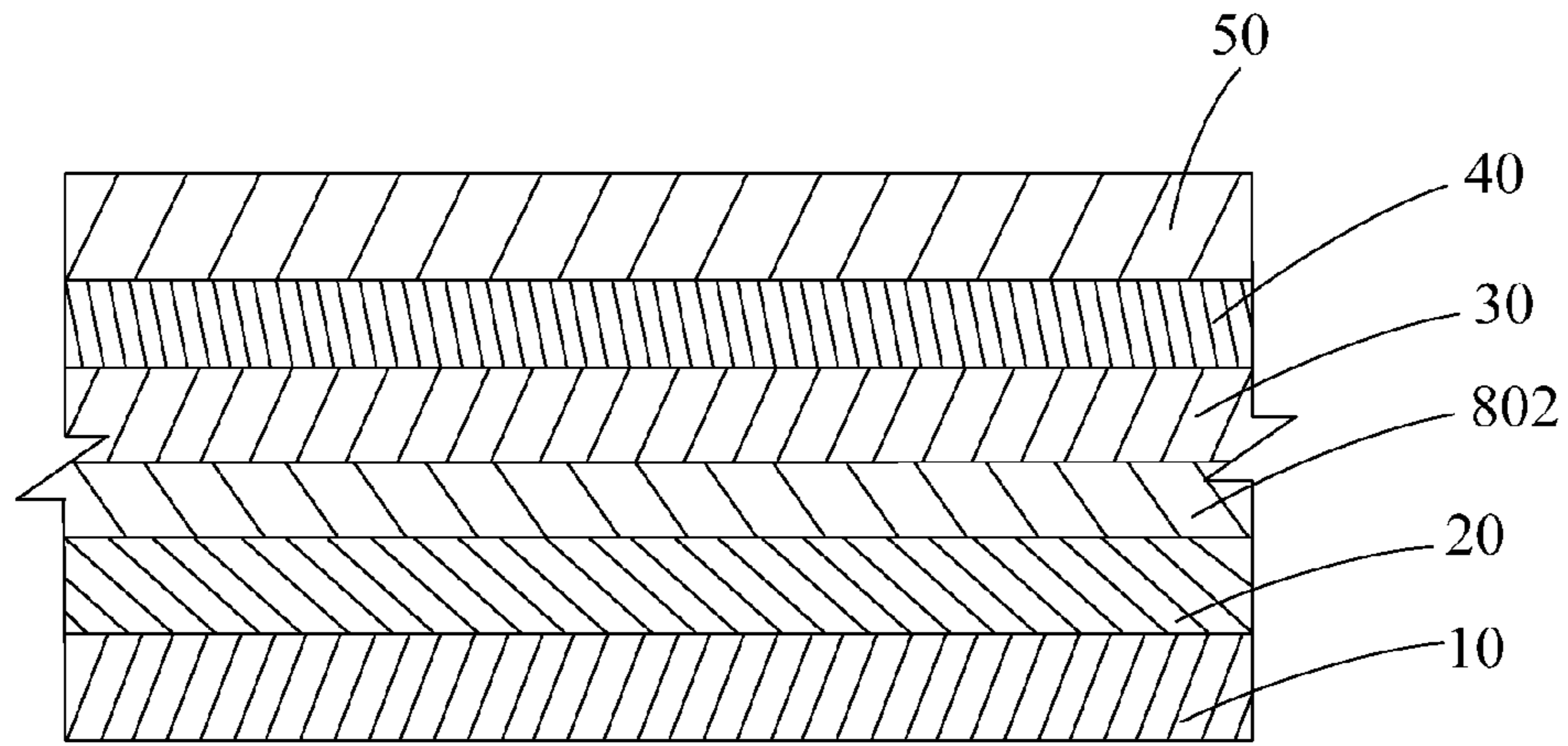


Fig. 3

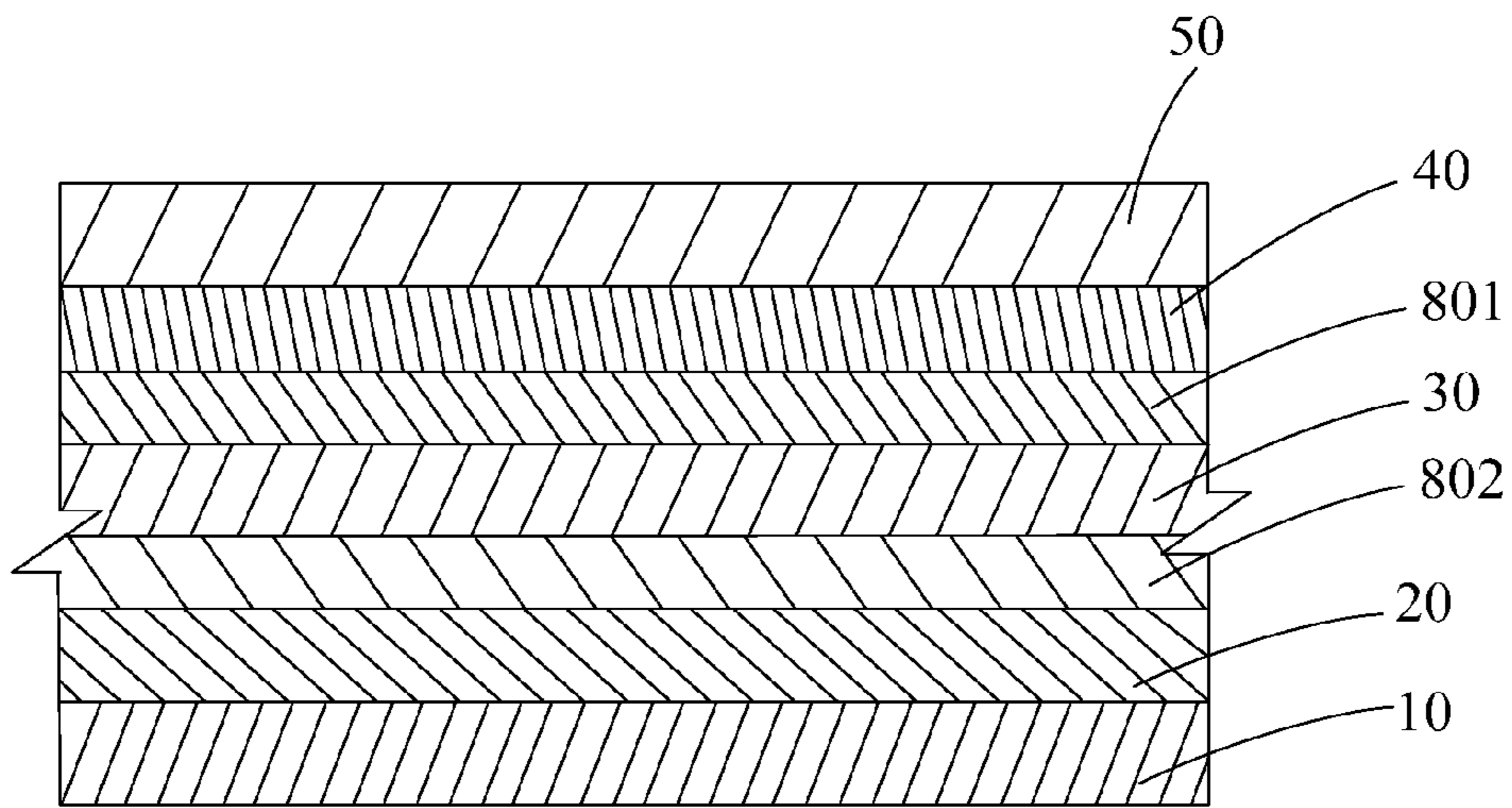


Fig. 4

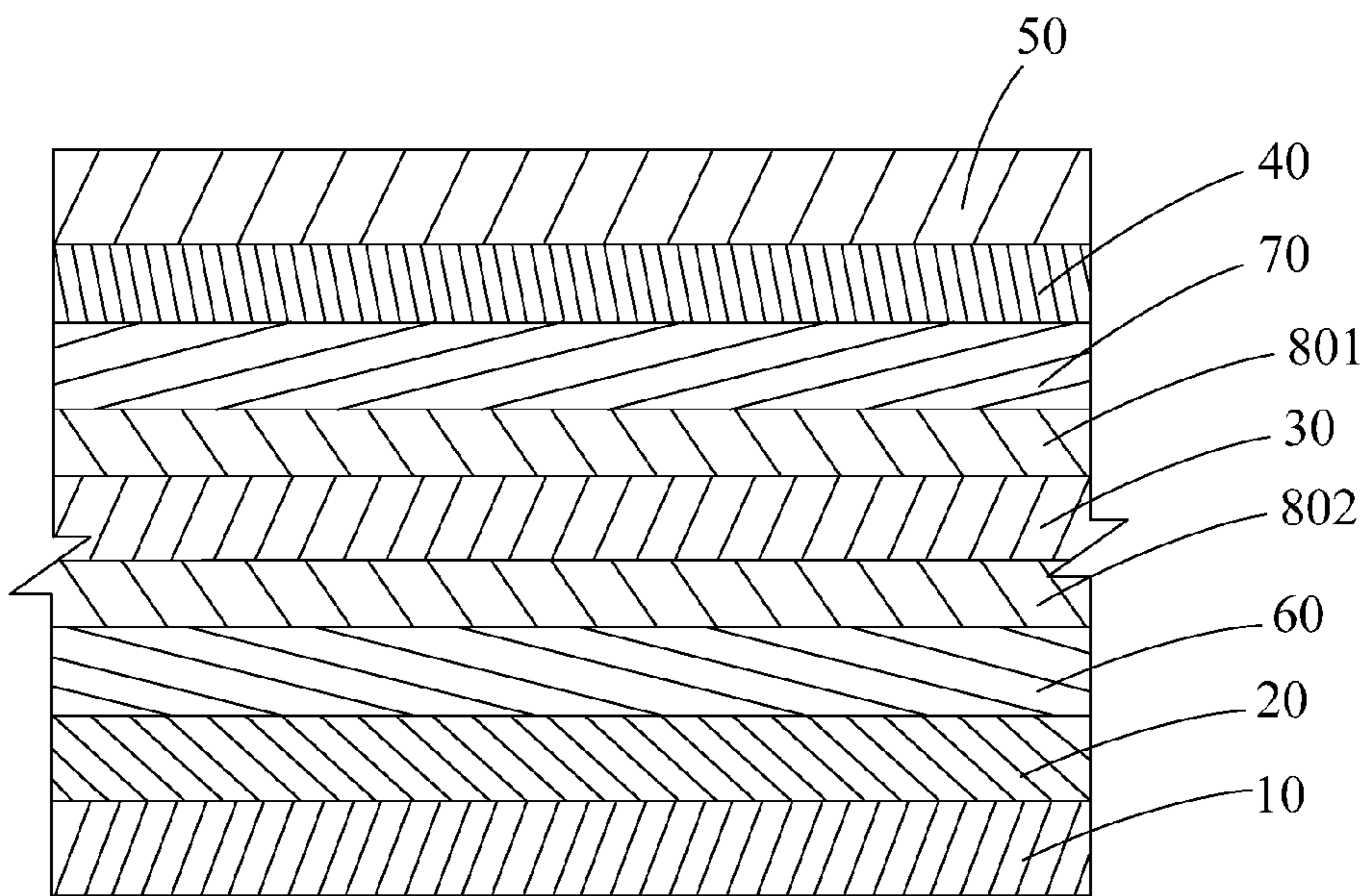


Fig. 5



**ORGANIC LIGHT-EMITTING DIODE  
FLUORESCENT DEVICE AND METHOD  
FOR PRODUCING SAME**

BACKGROUND OF THE INVENTION

The present invention relates to the field of display devices and, more particularly, to an organic light-emitting diode fluorescent device and a method for producing the organic light-emitting diode fluorescent device.

Organic light-emitting diodes (OLEDs) have received wide attention from the scientific society and the industries in recent years and OLED displays have entered the lives of people. The OLED display industry use organic material to accomplish the purpose of illuminating light of different colors, wherein red light devices and green light devices generally use phosphorescent material to achieve 100% internal quantum efficiency, while blue light devices still require much improvement in illuminating efficiency and service life as well as other aspects. The phosphorescent material responsible for blue light has a shorter service life, conventional blue light OLED devices generally use fluorescent system. However, the internal quantum efficiency of the fluorescent system is only 25%, and the remaining 75% of energy so generated is wasted, leading to a poor light emitting efficiency. Thus, it is an urgent issue to improve the efficiency and stability of the blue light devices.

BRIEF SUMMARY OF THE INVENTION

An objective of the present invention is to provide an organic light-emitting diode fluorescent device and a method for producing the organic light-emitting diode fluorescent device to fix the disadvantages of low internal quantum efficiency and poor light emitting efficiency of devices using fluorescent material.

In an aspect, an organic light-emitting diode fluorescent device includes an anode layer, a hole injection layer, an emissive layer, an electron injection layer, and a cathode layer. A confinement layer is disposed on at least one of an upper face and a lower face of the emissive layer. The confinement layer has a triplet energy level higher than a triplet energy level of the emissive layer.

In an example, the confinement layer includes a first confinement layer disposed on the upper face of the emissive layer. The first confinement layer is capable of transporting electrons and serves as an electron transport layer.

In another example, the confinement layer includes a first confinement layer disposed on the upper face of the emissive layer, and an electron transport layer is disposed between the first confinement layer and the electron injection layer.

The hole injection layer can have a hole injection capability larger than a hole injection capability of the electron injection layer.

In a further example, the confinement layer includes a second confinement layer disposed on the lower face of the emissive layer, and the second confinement layer is capable of transporting holes and serves as a hole transport layer.

In still another example, the confinement layer includes a second confinement layer disposed on the lower face of the emissive layer, and a hole transport layer is disposed between the second confinement layer and the hole injection layer.

In yet another example, the confinement layer includes a second confinement layer disposed on the lower face of the emissive layer, and the hole injection layer has a hole

injection capability smaller than a hole injection capability of the electron injection layer.

The material for the confinement layer includes TCTA (4,4',4''-Tris(carbazol-9-yl)triphenylamine) or P014 (2,8-Bis-(diphenylphosphinoyl)dibenzofuran).

In another aspect, a method for producing the organic light-emitting diode fluorescent device includes providing an anode substrate as an anode layer and disposing a hole injection layer, an emissive layer, an electron injection layer, and a cathode layer on the anode layer in sequence. The method further includes disposing a confinement layer on at least one of an upper face and a lower face of the emissive layer while producing the emissive layer. The confinement layer has a triplet energy level higher than a triplet energy level of the emissive layer.

In an example, disposing the confinement layer includes disposing a first confinement layer on the upper face of the emissive layer. The first confinement layer is located between the electron injection layer and the emissive layer. The first confinement layer is capable of transporting electrons and serves as an electron transport layer.

In another example, disposing the confinement layer includes disposing a first confinement layer on the upper face of the emissive layer and disposing an electron transport layer between the first confinement layer and the electron injection layer.

The hole injection layer can have a hole injection capability larger than a hole injection capability of the electron injection layer.

In a further example, disposing the confinement layer includes disposing a second confinement layer on the lower face of the emissive layer. The second confinement layer is located between the hole injection layer and the emissive layer. The second confinement layer is capable of transporting holes and serves as a hole transport layer.

In still another example, disposing the confinement layer includes disposing a second confinement layer on the lower face of the emissive layer and disposing a hole transport layer between the second confinement layer and the hole injection layer.

In yet another example, disposing the confinement layer includes disposing a second confinement layer on the lower face of the emissive layer. The hole injection layer has a hole injection capability smaller than a hole injection capability of the electron injection layer.

The material for the confinement layer can be TCTA (4,4',4''-Tris(carbazol-9-yl)triphenylamine) or P014 (2,8-Bis-(diphenylphosphinoyl)dibenzofuran).

The present invention will become clearer in light of the following detailed description of illustrative embodiments of this invention described in connection with the drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic cross sectional view of a conventional organic light-emitting diode in which a hole transport layer and an electron transport layer are omitted.

FIG. 2 is a diagrammatic cross sectional view of an organic light-emitting diode fluorescent device of a first embodiment according to the present invention.

FIG. 3 is a diagrammatic cross sectional view of an organic light-emitting diode fluorescent device of a second embodiment according to the present invention.

FIG. 4 is a diagrammatic cross sectional view of an organic light-emitting diode fluorescent device of a third embodiment according to the present invention.



FIG. 5 is a diagrammatic cross sectional view of an organic light-emitting diode fluorescent device of a fourth embodiment according to the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 is diagrammatic cross sectional view of a conventional organic light-emitting diode (OLED) device in which a hole transport layer and an electron transport layer are omitted. The conventional OLED device includes an anode layer 10, a hole injection layer 20, an emissive layer 30, an electron injection layer 40, and a cathode layer 50.

An OLED fluorescent device according to preferred embodiment of the present invention includes a confinement layer disposed on at least one of an upper face and a lower face of the emissive layer 30. The confinement layer has a triplet energy level higher than a triplet energy level of the emissive layer 30, such that the triplet excitons are confined in the emissive layer 30. The triplet excitons combine with each other to form singlet excitons to thereby obtain a fluorescence spectrum, improving the internal quantum efficiency of the fluorescent device. In an example, two confinement layers are respectively disposed on the upper and lower faces of the emissive layer 30, and the triplet energy level of each confinement layer is higher than the triplet energy level of the emissive layer 30, more effectively confining the triplet excitons in the emissive layer 30 to further improve the efficiency of the fluorescent device.

In another example, a confinement layer can be disposed on only one of the upper and lower faces of the emissive layer 30 according to the structure of the OLED fluorescent device. As an example, when the light emitting area in the emissive layer 30 is adjacent to the anode (namely, the hole injection capability of the hole injection layer 20 is smaller than the hole injection capability of the electron injection layer 40), a confinement layer can be disposed between the emissive layer 30 and the hole injection layer 20 (i.e., the lower face of the emissive layer 30). In another case that the light emitting area in the emissive layer 30 is adjacent to the cathode (namely, the hole injection capability of the hole injection layer 20 is larger than the hole injection capability of the electron injection layer 40), a confinement layer can be disposed between the emissive layer 30 and the electron injection layer 40 (i.e., the upper face of the emissive layer 30). Disposing a confinement layer on only one of the upper and lower faces of the emissive layer 30 can simplify the structure of the fluorescent device while improving the efficiency of the fluorescent device. Embodiments of the OLED fluorescent device and the method for producing the embodiments of the OLED fluorescent device will be set forth hereinafter.

The conventional OLED includes, from bottom to top, an anode layer 10, a hole injection layer 20, an emissive layer 30, an electron injection layer 40, and a cathode layer 50, as shown in FIG. 1. The emissive layer 30 includes an upper face 301 and a lower face 302. The upper face 301 is bonded to the electron injection layer 40. The lower face 302 is bonded to the hole injection layer 20.

The organic light-emitting diode fluorescent device according to the present invention is constructed based on the above structure. A confinement layer is disposed on at least one of the upper face 301 and the lower face 302 of the emissive layer 30. In different embodiments, the confinement layer is disposed on the upper face 301 of the emissive layer 30, on the lower face 302 of the emissive layer 30, and on each of the upper face 301 and the lower face 302 of the

emissive layer 30, respectively. The triplet energy level of the confinement layer is higher than the triplet energy level of the emissive layer 30 to confine the triplet excitons in the emissive layer 30. The triplet excitons combine with each other to form singlet excitons to thereby obtain a delayed fluorescence spectrum, improving the internal quantum efficiency of the fluorescent device and improving the light emitting efficiency of the fluorescent device.

The confinement layer is a triplet exciton confinement layer (TECL). The material for the confinement layer can be 4,4',4''-Tris(carbazol-9-yl)triphenylamine (TCTA) or 2,8-Bis-(diphenylphosphinoyl)dibenzofuran (P014). The material characteristics of the above materials are shown in Table 1.

TABLE 1

Material Characteristics Parameters of TCTA and P014			
TECL material	highest occupied molecular orbit	lowest unoccupied molecular orbit	triplet energy level
TCTA	-5.1	-1.7	2.9
P014	-6.5	-2.5	3.1

Combination of the triplet excitons forming the singlet excitons fulfills the following Equation (1):

$${}^3A^* + {}^3A^* \rightarrow (4/9){}^1A^* + (1/9){}^1A^* + (13/9){}^3A^* \quad (1)$$

wherein  ${}^3A^*$  is a triplet exciton and  ${}^1A^*$  is a singlet exciton.

As can be seen from Equation (1), five (5) triplet excitons can generate a singlet exciton. The original internal quantum efficiency of the fluorescent device is 25%, and the remaining 75% of triplet excitons cannot emit light. By disposing the confinement layer to confine the triplet excitons in the emissive layer 30 such that the triplet excitons combine with each other to form singlet excitons capable of emitting light, the 75% of triplet excitons can be converted into 15% of singlet excitons, increasing the internal quantum efficiency from 25% to 40%. Thus, the efficiency of the OLED fluorescent device is increased by 60%.

FIG. 2 is a diagrammatic cross sectional view of an OLED fluorescent device of a first embodiment according to the present invention. In this embodiment, the OLED fluorescent device includes an anode layer 10, a hole injection layer 20, an emissive layer 30, a first confinement layer 801, an electron injection layer 40, and a cathode layer 50 in sequence. The first confinement layer 801 is located between the electron injection layer 40 and the emissive layer 30 and is disposed on the upper face 301 of the emissive layer 30. The first confinement layer 801 is capable of transporting electrons and serves as an electron transport layer. The triplet energy level of the first confinement layer 801 is higher than the triplet energy level of the emissive layer 30. In this embodiment, the hole injection capability of the hole injection layer 20 is larger than the hole injection capability of the electron injection layer 40; namely, the light emitting area of the emissive layer 30 is adjacent to the cathode. A suitable material for an electron transport layer is selected as the material for the first confinement layer 801, has a triplet energy level higher than the triplet energy level of the emissive layer 30, and is capable of transporting electrons. The first confinement layer 801 can be made of PO14 (2,8-Bis-(diphenylphosphinoyl)dibenzofuran). In a preferred example of this embodiment, an electron transport layer is disposed between the first confinement layer 801 and the electron injection layer 40. In this case, the material for



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the first confinement layer **801** can only fulfill the requirement of having a triplet energy level higher than the triplet energy level of the emissive layer **30**. The electron transport capability is not required.

FIG. **3** is a diagrammatic cross sectional view of an organic light-emitting diode fluorescent device of a second embodiment according to the present invention. In the second embodiment, the OLED fluorescent device includes an anode layer **10**, a hole injection layer **20**, a second confinement layer **802**, an emissive layer **30**, an electron injection layer **40**, and a cathode layer **50** in sequence. The second confinement layer **802** is located between the hole injection layer **20** and the emissive layer **30** and is disposed on the lower face **302** of the emissive layer **30**. The second confinement layer **802** is capable of transporting holes and serves as a hole transport layer. The triplet energy level of the second confinement layer **802** is higher than the triplet energy level of the emissive layer **30**. In this embodiment, the hole injection capability of the hole injection layer **20** is smaller than the hole injection capability of the electron injection layer **40**; namely, the light emitting area of the emissive layer **30** is adjacent to the anode. A suitable material for a hole transport layer is selected as the material for the second confinement layer **802**, has a triplet energy level higher than the triplet energy level of the emissive layer **30**, and is capable of transporting holes. The second confinement layer **802** can be made of TCTA (4,4',4"-Tris(carbazol-9-yl)triphenylamine). In a preferred example of this embodiment, a hole transport layer is disposed between the second confinement layer **802** and the hole injection layer **20**. In this case, the material for the second confinement layer **802** can only fulfill the requirement of having a triplet energy level higher than the triplet energy level of the emissive layer **30**. The hole transport capability is not required.

FIG. **4** is a diagrammatic cross sectional view of an organic light-emitting diode fluorescent device of a third embodiment according to the present invention. In the third embodiment, the OLED fluorescent device includes an anode layer **10**, a hole injection layer **20**, a second confinement layer **802**, an emissive layer **30**, a first confinement layer **801**, an electron injection layer **40**, and a cathode layer **50** in sequence. The first confinement layer **801** and the second confinement layer **802** are respectively disposed on the upper and lower faces **301** and **302** of the emissive layer **30**. The triplet energy level of each of the first and second confinement layers **801** and **802** is higher than the triplet energy level of the emissive layer **30**. The first confinement layer **801** is capable of transporting electrons and serves as an electron transport layer. The second confinement layer **802** is capable of transporting holes and serves as a hole transport layer. A suitable material for an electron transport layer is selected as the material for the first confinement layer **801**, has a triplet energy level higher than the triplet energy level of the emissive layer **30**, and is capable of transporting electrons. The first confinement layer **801** can be made of P014 (2,8-Bis-(diphenylphosphinoyl)dibenzofuran). A suitable material for a hole transport layer is selected as the material for the second confinement layer **802**, has a triplet energy level higher than the triplet energy level of the emissive layer **30**, and is capable of transporting holes. The second confinement layer **802** can be made of TCTA (4,4',4"-Tris(carbazol-9-yl)triphenylamine).

FIG. **5** is a diagrammatic cross sectional view of an organic light-emitting diode fluorescent device of a fourth embodiment according to the present invention. In the fourth embodiment, the OLED fluorescent device includes an

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anode layer **10**, a hole injection layer **20**, a hole transport layer **60**, a second confinement layer **802**, an emissive layer **30**, a first confinement layer **801**, an electron transport layer **70**, an electron injection layer **40**, and a cathode layer **50** in sequence. The first confinement layer **801** and the second confinement layer **802** are respectively disposed on the upper and lower faces of the emissive layer **30**. The triplet energy level of each of the first and second confinement layers **801** and **802** is higher than the triplet energy level of the emissive layer **30**.

The advantageous effects of the OLED fluorescent device according to the present invention include:

The OLED fluorescent device according to the present invention is suitable for fluorescent device systems including red, green, and blue light fluorescent devices.

By disposing the confinement layer **801**, **802** (having a triplet energy level higher than the triplet energy level of the emissive layer **30**) on the emissive layer **30** to confine the triplet excitons in the emissive layer **30**, the combination possibility of the triplet excitons is increased such that the triplet excitons combine with each other to form singlet excitons, thereby obtaining a fluorescence spectrum. Thus, the internal quantum efficiency of the fluorescent device is increased from 25% to 40%, and the efficiency of the fluorescent device is increased by 60%.

The materials of the confinement layers **801** and **802** can be selected to include the capability of transporting electrons and holes to simplify the structure of the device without adversely affecting the light emitting function of the fluorescent device.

A method for producing the embodiments of the OLED fluorescent device will now be set forth.

With reference to FIG. **1**, the method for producing an organic light-emitting diode fluorescent device includes providing an anode substrate as an anode layer **10** and disposing a hole injection layer **20**, an emissive layer **30**, an electron injection layer **40**, and a cathode layer **50** on the anode layer **10** in sequence. A confinement layer is disposed on at least one of an upper face **301** and a lower face **302** of the emissive layer **30** while producing the emissive layer **30**. The confinement layer has a triplet energy level higher than a triplet energy level of the emissive layer **30**.

In an example, the confinement layer is disposed on the upper face **301** of the emissive layer **30** and is disposed between the emissive layer **30** and the electron injection layer **40**. In another example, the confinement layer is disposed in the lower face **302** of the emissive layer **30** and is disposed between the hole injection layer **20** and the emissive layer **30**. In a further example, a confinement layer is disposed on each of the upper and lower faces **301** and **302** of the emissive layer **30**. The confinement layer has a triplet energy level higher than a triplet energy level of the emissive layer **30**, such that the triplet excitons are confined in the emissive layer **30**. The triplet excitons combine with each other to form singlet excitons to thereby obtain a fluorescence spectrum, improving the internal quantum efficiency of the fluorescent device and improving the light emitting efficiency of the fluorescent device. The material for the confinement layer can be TCTA (4,4',4"-Tris(carbazol-9-yl)triphenylamine) or P014 (2,8-Bis-(diphenylphosphinoyl)dibenzofuran).

With reference to FIG. **2**, in a first embodiment of the method according to the present invention, a first confinement layer **801** is disposed on the upper face **301** of the emissive layer **30**. The first confinement layer **801** serves as an electron transport layer and is capable of transporting electrons. In this case, the hole injection capability of the



hole injection layer **20** is larger than the hole injection capability of the electron injection layer **40**. A suitable material for an electron transport layer is selected as the material for the first confinement layer **801**, has a triplet energy level higher than the triplet energy level of the emissive layer **30**, and is capable of transporting electrons. The first confinement layer **801** can be made of PO14 (2,8-Bis-(diphenylphosphinoyl)dibenzofuran). In a preferred example of this embodiment, an electron transport layer is disposed between the first confinement layer **801** and the electron injection layer **40**. In this case, the material for the first confinement layer **801** can only fulfill the requirement of having a triplet energy level higher than the triplet energy level of the emissive layer **30**.

With reference to FIG. 3, in a second embodiment of the method according to the present invention, a second confinement layer **802** is disposed on the lower face **302** of the emissive layer **30**. The second confinement layer **802** serves as a hole transport layer and is capable of transporting holes. The hole injection capability of the hole injection layer **20** is smaller than the hole injection capability of the electron injection layer **40**. A suitable material for a hole transport layer is selected as the material for the second confinement layer **802**, has a triplet energy level higher than the triplet energy level of the emissive layer **30**, and is capable of transporting holes. The second confinement layer **802** can be made of TCTA (4,4',4''-Tris(carbazol-9-yl)triphenylamine). In a preferred example of this embodiment, a hole transport layer is disposed between the second confinement layer **802** and the hole injection layer **20**. In this case, the material for the second confinement layer **802** can only fulfill the requirement of having a triplet energy level higher than the triplet energy level of the emissive layer **30**.

With reference to FIG. 4, in a third embodiment of the method according to the present invention, a first confinement layer **801** is disposed on the upper face **301** of the emissive layer **30**, and a second confinement layer **802** is disposed on the lower face **302** of the emissive layer **30**. The first confinement layer **801** is capable of transporting electrons and serves as an electron transport layer. The second confinement layer **802** is capable of transporting holes and serves as a hole transport layer. The materials for the first confinement layer **801** and the second confinement layer **802** can be selected in a manner mentioned above. In a preferred embodiment shown in FIG. 5, an electron transport layer **70** is disposed between the first confinement layer **801** and the electron injection layer **40**, and a hole transport layer **60** is disposed between the second confinement layer **802** and the hole injection layer **20**. In this case, the materials for the first confinement layer **801** and the second confinement layer **802** can only fulfill the requirement of having a triplet energy level higher than the triplet energy level of the emissive layer **30**.

The advantageous effects of the method for producing an OLED fluorescent device according to the present invention include:

The method for producing an OLED fluorescent device according to the present invention is suitable for fluorescent device systems including red, green, and blue light fluorescent devices.

By disposing the confinement layer **801**, **802** (having a triplet energy level higher than the triplet energy level of the emissive layer **30**) on the emissive layer **30** to confine the triplet excitons in the emissive layer **30**, the merge possibility of the triplet excitons is increased such that the triplet excitons combine with each other to form singlet excitons, thereby obtaining a fluorescence spectrum. Thus, the inter-

nal quantum efficiency of the fluorescent device is increased from 25% to 40%, and the efficiency of the fluorescent device is increased by 60%.

The materials of the confinement layers **801** and **802** can be selected to include the capability of transporting electrons and holes to simplify the structure of the fluorescent device without adversely affecting the light emitting function of the fluorescent device.

Thus since the illustrative embodiments disclosed herein may be embodied in other specific forms without departing from the spirit or general characteristics thereof, some of which forms have been indicated, the embodiments described herein are to be considered in all respects illustrative and not restrictive. The scope is to be indicated by the appended claims, rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are intended to be embraced therein.

The invention claimed is:

**1.** In an organic light-emitting diode fluorescent device comprising an anode layer, a hole injection layer, an emissive layer, an electron injection layer, and a cathode layer, wherein the improvement comprises:

a first confinement layer disposed between the cathode layer and the emissive layer and having a triplet energy level higher than a triplet energy level of the emissive layer,

wherein the first confinement layer is disposed on an upper face of the emissive layer, and wherein the first confinement layer is capable of transporting electrons and serves as an electron transport layer.

**2.** The device as claimed in claim 1, wherein the first confinement layer is disposed on an upper face of the emissive layer, and wherein an electron transport layer is disposed between the first confinement layer and the electron injection layer.

**3.** The device as claimed in claim 2 further comprising a second confinement layer disposed on the lower face of the emissive layer; and a hole transport layer disposed between the second confinement layer and the hole injection layer.

**4.** The device as claimed in claim 1, wherein the hole injection layer has a hole injection capability larger than a hole injection capability of the electron injection layer.

**5.** The device as claimed in claim 1, further comprising a second confinement layer disposed on the lower face of the emissive layer, and wherein the second confinement layer is capable of transporting holes and serves as a hole transport layer.

**6.** The device as claimed in claim 1, further comprising a second confinement layer disposed on the lower face of the emissive layer, and wherein a hole transport layer is disposed between the second confinement layer and the hole injection layer.

**7.** The device as claimed in claim 1, further comprising a second confinement layer disposed on the lower face of the emissive layer, and wherein the hole injection layer has a hole injection capability smaller than an electron injection capability of the electron injection layer.

**8.** The device as claimed in claim 1, wherein a material for the confinement layer is 4,4',4''-Tris(carbazol-9-yl) triphenylamine or 2,8-Bis-(diphenylphosphinoyl) dibenzofuran.

**9.** The device as claimed in claim 1 further comprising a second confinement layer disposed on the lower face of the emissive layer, with the second confinement layer capable of transporting holes and serving as a hole transport layer.



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**10.** A method for producing an organic light-emitting diode fluorescent device, the method comprising the steps of:

providing an anode substrate as an anode layer;  
 disposing a hole injection layer, an emissive layer, an  
 electron injection layer, and a cathode layer on the  
 anode layer in sequence;

disposing a first confinement layer between the emissive  
 layer and the cathode layer while producing the emis-  
 sive layer, wherein the confinement layer has a triplet  
 energy level higher than a triplet energy level of the  
 emissive layer;

wherein the first confinement layer disposing step  
 includes disposing the first confinement layer on the  
 upper face of the emissive layer, wherein the first  
 confinement layer is located between the electron injec-  
 tion layer and the emissive layer, and wherein the first  
 confinement layer is capable of transporting electrons  
 and serves as an electron transport layer.

**11.** The method as claimed in claim **10**, wherein the first  
 confinement layer disposing step includes disposing the first  
 confinement layer on the upper face of the emissive layer  
 and disposing an electron transport layer between the first  
 confinement layer and the electron injection layer.

**12.** The method as claimed in claim **10**, wherein the hole  
 injection layer has a hole injection capability larger than a  
 hole injection capability of the electron injection layer.

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**13.** The method as claimed in claim **10**, further compris-  
 ing the step of disposing a second confinement layer on the  
 lower face of the emissive layer, wherein the second con-  
 finement layer is located between the hole injection layer  
 and the emissive layer, and wherein the second confinement  
 layer is capable of transporting holes and serves as a hole  
 transport layer.

**14.** The method as claimed in claim **13**, comprising  
 disposing a hole transport layer between the second con-  
 finement layer and the hole injection layer.

**15.** The method as claimed in claim **10**, further compris-  
 ing the step of disposing a second confinement layer on the  
 lower face of the emissive layer and disposing a hole  
 transport layer between the second confinement layer and  
 the hole injection layer.

**16.** The method as claimed in claim **15**, wherein the  
 second confinement layer is located between the hole injec-  
 tion layer and the emissive layer, and wherein the second  
 confinement layer is capable of transporting holes and serves  
 as a hole transport layer.

**17.** The method as claimed in claim **10**, wherein the hole  
 injection layer has a hole injection capability smaller than a  
 hole injection capability of the electron injection layer.

**18.** The method as claimed in claim **10**, wherein a material  
 for the confinement layer is 4,4',4''-Tris(carbazol-9-yl) tri-  
 phenylamine or 2,8-Bis-(diphenylphosphino) dibenzo-  
 furan.

\* \* \* \* \*